

# **FIELD BUS INTEROPERABILITY TESTING AND SYSTEM CONFIGURATION**

By

**MOHAMED ZAHER MOHAMED ALY ZAHER  
8003**

**FINAL REPORT**

**Submitted to the Electrical & Electronics Engineering Programme  
in Partial Fulfilment of the Requirements  
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**Universiti Teknologi Petronas  
Bandar Seri Iskandar  
31750 Tronoh  
Perak Darul Ridzuan**

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# **CERTIFICATION OF APPROVAL**

## **FIELDBUS INTEROPERABILITY TESTING AND SYSTEM CONFIGURATION**

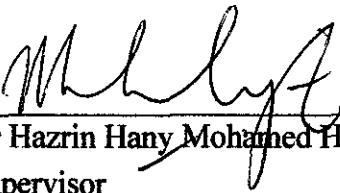
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A project dissertation submitted to the  
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Universiti Teknologi PETRONAS  
in partial fulfillment of the requirement for the  
Bachelor of Engineering (Hons)  
(Electrical & Electronics Engineering)

Approved:

  
\_\_\_\_\_  
Mrs. Noor Hazrin Hany Mohamed Hanif  
Project Supervisor

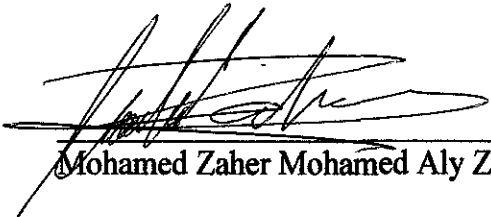
**UNIVERSITI TEKNOLOGI PETRONAS**

**TRONOH, PERAK**

**December 2009**

## CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



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Mohamed Zaher Mohamed Aly Zaher

## **ABSTRACT**

This report is to discuss the research and Basic Interoperability testing for Foundation Fieldbus system, as well as the development of a control loop. Devices that use Foundation Fieldbus system cannot interoperate with devices from different manufacturers. PETRONAS as the established company will apply Fieldbus technology in its plants. The objectives of the testing are to get a PETRONAS Technical standard on the Foundation Fieldbus system and come out with a report on the results from interoperability testing that will be the reference for system in PETRONAS. The other objective is to test the controller performance using the three control modes, P, PI and PID. In order to achieve the objectives, first three tests should be done, basic interoperability test, Stress test and Diagnostic capability, and then a test on the controller performance will be held. Due to time constraint, UTP team was able to complete the Basic interoperability test and the control loop development. The author will only focus on testing HONEYWELL system and segment 2, provided by MTL. The Basic interoperability test was successfully done and the controller performance was successfully tested. The research about the Foundation Fieldbus should be performed continuously, to improve the system from time to time, and the analysis of results and reports will be used for future researches.

## **ACKNOWLEDGEMENT**

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May this project help out anyone in the process of understanding what Fieldbus is and how to operate Fieldbus system.

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# **CHAPTER 1**

## **INTRODUCTION**

### **1.1 Background of Study**

Fieldbus was first developed in the 1980s, fieldbus superseded earlier network protocols due to its ability to easily distribute control across the process, move large amounts of data throughout the plant, and integrate that data within and between control subsystems. In 1994, Fieldbus technology took a promising new direction. Two major suppliers, the InterOperable Systems Project (ISP) and WorldFIP North America, merged to form the Foundation Fieldbus. The new consortium organized development programs, conducted field trials, and established the industry's most accurate programs for testing and registering Fieldbus devices. [1]

The foundation Fieldbus Interpretability test will involve UTP team and SKG 14 TP's team. The foundation Fieldbus was supplied and installed at UTP by four vendors: Honeywell, Emerson, Foxboro and Yokogawa.

### **1.2 Problem Statement**

Adapting to use a Fieldbus system requires some comprehensive studies on the interpretability of Fieldbus system which are not well versed. The interoperability of FOUNDATION Fieldbus will involve the ability of communication between different devices and host of different vendors, since for each vendor there is a different

protocol. Although it is one of the best systems used nowadays but the efficiency of communication between different hosts and devices should be measured.

The outcome of the tests will become the reference to the production of a PETRONAS approved list for FOUNDATION Fieldbus system and field devices.

### **1.3 Objectives**

The objectives of the project are

- Understanding and familiarizing with Foundation Fieldbus system, especially HONEYWELL system
- Perform Basic interoperability testing using HONEYWELL system, in order to use it as a reference for Foundation Fieldbus system in PETRONAS
- Develop a plant model for a simple control loop using HONEYWELL system

### **1.4 Scope Of Study**

Scopes of activities of the Fieldbus interoperability test and system configuration are:

- To understand the Foundation Fieldbus system
- To familiarize with HONEYWELL System.
- To perform interoperability test using HONEYWELL Host.
- Come out with technical report that will be used as reference for Foundation Fieldbus system in PETRONAS and ensure all testing meet PETRONAS standards on foundation Fieldbus system.
- Testing the controller performance, by developing a plant model for a simple control loop.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Fieldbus Overview**

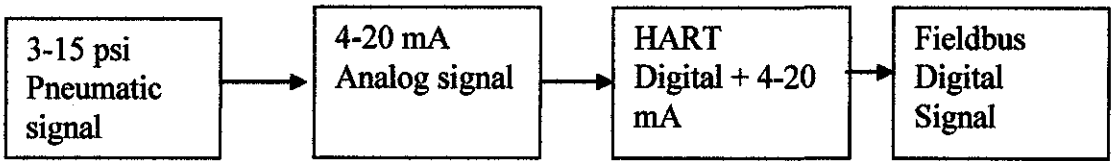
Fieldbus is a generic-term which describes a new digital communications network which will be used in industry to replace the existing 4 - 20mA analogue signal. The network is a digital, bi-directional, multi-drop, serial-bus, communications network used to link isolated field devices, such as controllers, transducers, actuators and sensors. Each field device has low cost computing power installed in it, making each device a 'smart' device. Each device will be able to execute simple functions on its own such as diagnostic, control, and maintenance functions as well as providing bi-directional communication capabilities. With these devices not only will the engineer be able to access the field devices, but they are also able to communicate with other field devices. In essence Fieldbus will replace centralized control networks with distributed-control networks. Therefore Fieldbus is much more than a replacement for the 4 - 20mA analogue standard. [2]

The Fieldbus technology promises to improve quality, reduce costs and boost efficiency. These promises made by the Fieldbus technology are derived partly from the fact that information which a field device is required to transmit or receive can be transmitted digitally. This is a great deal more accurate than transmitting using analogue methods which were used previously. Each field device is also a 'smart'

device and can carry out its own control, maintenance and diagnostic functions. As a result it can report if there is a failure of the device or manual calibration is required,

this increases the efficiency of the system and reduces the amount of maintenance required. [3]

Each field device will be more flexible as they will have computing power. One Fieldbus device could be used to replace a number of devices using the 4 - 20mA analogue standard. Other major cost savings from using Fieldbus are due to wiring and installation - the existing 4 - 20mA analogue signal standard requires each device to have its own set of wires and its own connection point. Fieldbus eliminates this need so only a single twisted pair wiring scheme is required.



**Figure 1: Evolution of signal standards**

**Table 1: Evolution of signal transmitting technology**

<b>Year</b>	<b>Technology</b>	<b>Advantages</b>	<b>Disadvantages</b>
1940-1970	<b>3-15 psi Pneumatic</b>	-Field device can be installed at hazardous area	-Devices are large in size -Field devices have limited distances
1960-1980	<b>4-20 mA Analog</b>	-Field device distance can be extended to 1000 m	-Requires field barrier to limit the current
1980-1990	<b>HART Digital + 4-20 mA</b>	-Supported by many vendors	-Still depends on analog technology -each instrument needs one instrument cable signal pair
1990-now	<b>Fieldbus</b>	-Digital -Allows migration of control functions closer to field device	-Less experience in this technology -Interoperability issue

## **2.2 Advantages of Foundation Fieldbus**

The fieldbus has plenty of advantages that the end users will benefit from. The major advantage of the fieldbus and the most attractive to the end user is the reduction in costs. [4]

The field bus has additional advantage over 4-20 mA because many devices can connect to a single wire pair resulting in significant savings in wiring costs. Instead of reducing the wiring requirements, the fieldbus also decrease the installation and equipment costs as well. [2]

The other advantage that end user can get from using fieldbus technology is by delivering system self-diagnostics which can support predictive or preventive plant maintenance.

## **2.3 Fieldbus Topology**

There are four commonly used FIELDBUS topologies named Point-to-Point topology, Tree topology (chicken foot), Spur topology and Daisy Chain topology

- **Point-to-Point:**

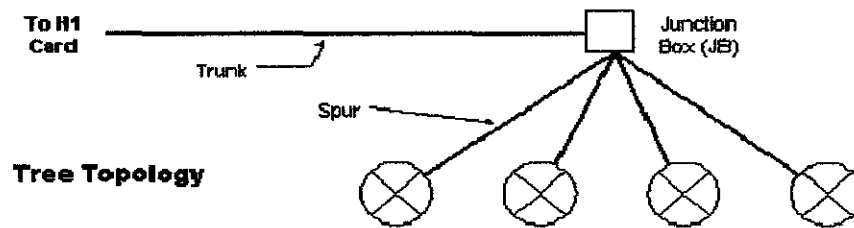
This topology consists of a network having only two devices. The network could be entirely in the field (e.g. a transmitter and valve, with no connection beyond the two) or it could be a field device connected to a host system (doing control or monitoring). [5]



**Figure 2: Point-to-Point topology**

- **Tree topology (chicken foot):**

This topology consists of a single FIELDBUS segment connected to a common junction box to form a network. This topology can be used at the end of a home run cable. It is practical if the devices on the same segment are well separated but in the general area of the junction box. When using this topology, the maximum spur lengths must be considered. [5]

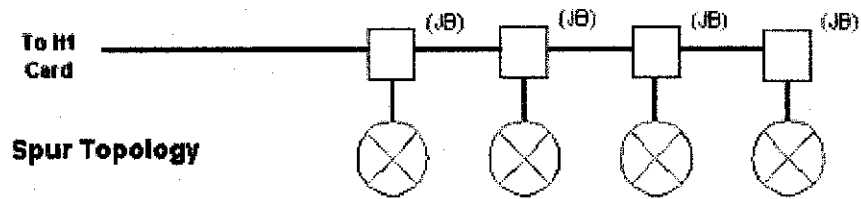


**Figure 3: Tree topology**

- **Spur topology:**

This topology consists of FIELDBUS devices that are connected to a multi-drop bus segment through a length of cable called a spur. This technology is technically acceptable but not generally a good economic choice. Bus with spur topology should be used in new installations that have a low density of devices in an area. [5]

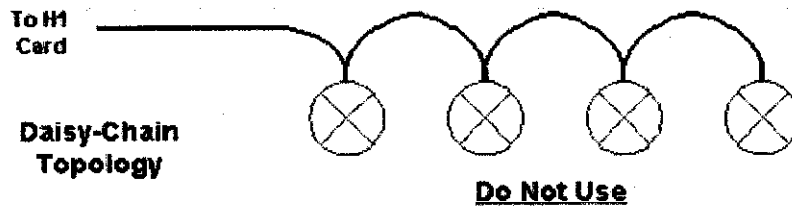




**Figure 4: Spur topology**

- **Daisy Chain topology:**

This topology consists of a network/ segment that is routed from device to device and is connected at the terminals of the FIELDBUS device. This topology should not be used since it is unacceptable for maintenance purposes. [5]



**Figure 5: Daisy-Chain topology**

In this project, Chicken-foot topology will be used since the standard practice in PETRONAS is implementing this topology.

2.4 Foundation Fieldbus

Foundation Fieldbus enables the connection of various field devices and operation stations. Fieldbus Network can consist of one or more segments; multiple segments are connected through repeaters or other devices which contain the repeater (Field Barier).

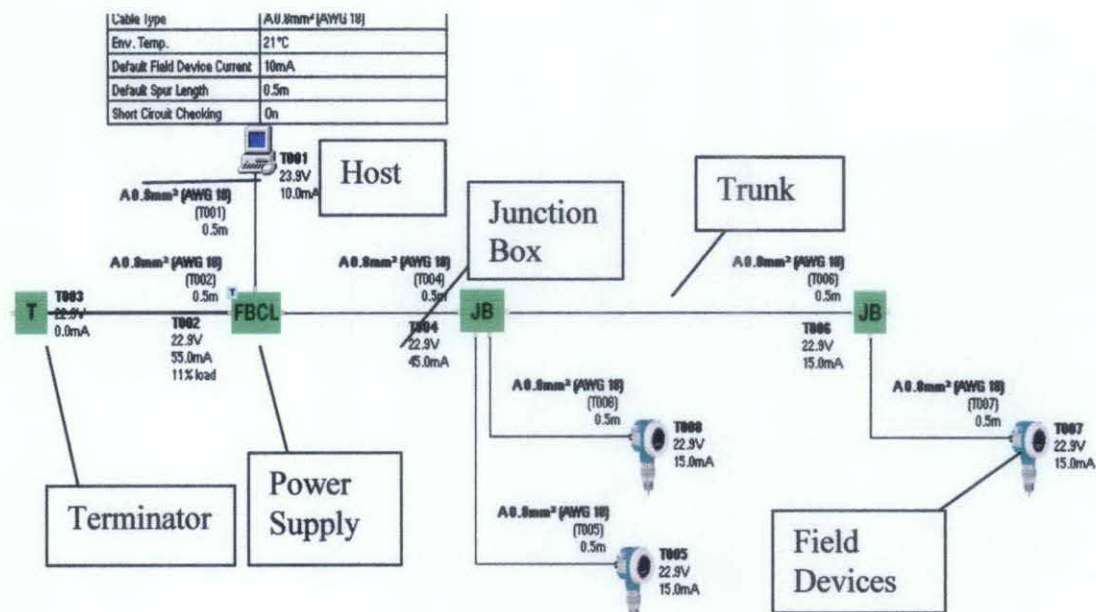
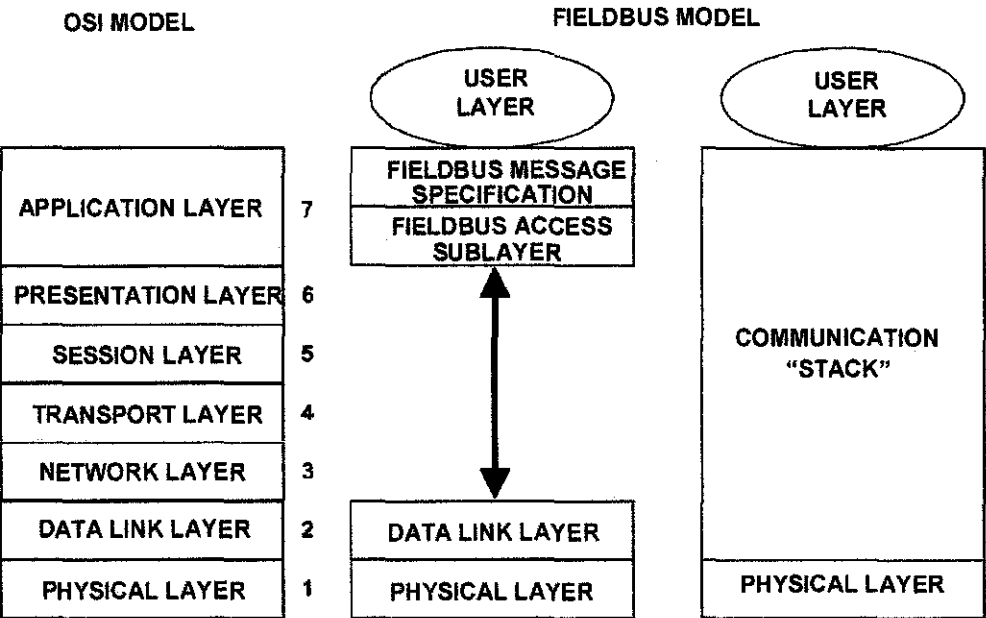


Figure 6: Common FF configuration (Designed using P+F Segment Checker)

The figure above shows a typical Fieldbus Configuration. The common FF configuration is twisted pair trunk cable connects the control equipments with the field devices. The trunk should connect the host to the field devices. Field devices are connected with a spur cable to a junction box. Spur is a cable that branches out from the trunk to each device

2.5    **Fieldbus Layers**

Foundation Fieldbus communication layers consists of the physical layer, the communication stack, and the user layer. The figure shows a diagram of the Fieldbus layers compared to the Open Systems Interconnect (OSI) layered communication model. Notice that the OSI model does not define a user layer.



**Figure 7: Communication Layers**

Foundation Fieldbus does not implement layers three, four, five, and six of the OSI model because the services of these layers are not required in a process control application. A very important part of Foundation Fieldbus is the defined user layer, often referred to as layer eight.

The physical layer converts digital Fieldbus messages from the communication stack to physical signals on the Fieldbus transmission medium and vice versa. The communication stack performs the services required to

interface the user layer to the physical layer. The communication stack consists of three layers: the Fieldbus Message Specification, the Fieldbus Access Sublayer, and the Data Link Layer. The communication stack encodes and decodes user layer messages and ensures efficient and accurate message transfer.

The Data Link Layer manages access to the Fieldbus through the Link Active Scheduler by splitting data into frames to send on the physical layer, receiving acknowledgment frames, and re-transmitting frames if they are not received correctly. It also performs error checking to maintain a sound virtual channel to the next layer. The Fieldbus Access Sub layer provides an interface between the Data Link Layer and the Fieldbus Message Specification layer. Within the Fieldbus Messaging Specification layer are two management layers called System Management and Network Management. System Management assigns addresses and physical device tags, maintains the function block schedule for the function blocks in that device, and distributes application time. You can also locate a device or a function block tag through System Management.

The user layer provides the interface for user interaction with the system. The user layer uses the device description to tell the host system about device capabilities. The user layer defines blocks and objects that represent the functions and data available in a device. Rather than interfacing to a device through a set of commands, like most communication protocols, Foundation Fieldbus lets you interact with devices through a set of blocks and objects that define device capabilities in a standardized way. [6]

## **2.6 The interoperability Test**

In order to achieve the interoperability for fieldbus devices, all the layers must be able to interoperate. The foundation fieldbus requires that each of the fieldbus resident devices must successfully complete several formal tests to ensure that all layers interoperate. The tests are physical layer test, conformance test and interoperability test. In this project only the interoperability test will be highlighted. [7]

## **2.7 Foundation Fieldbus implementing**

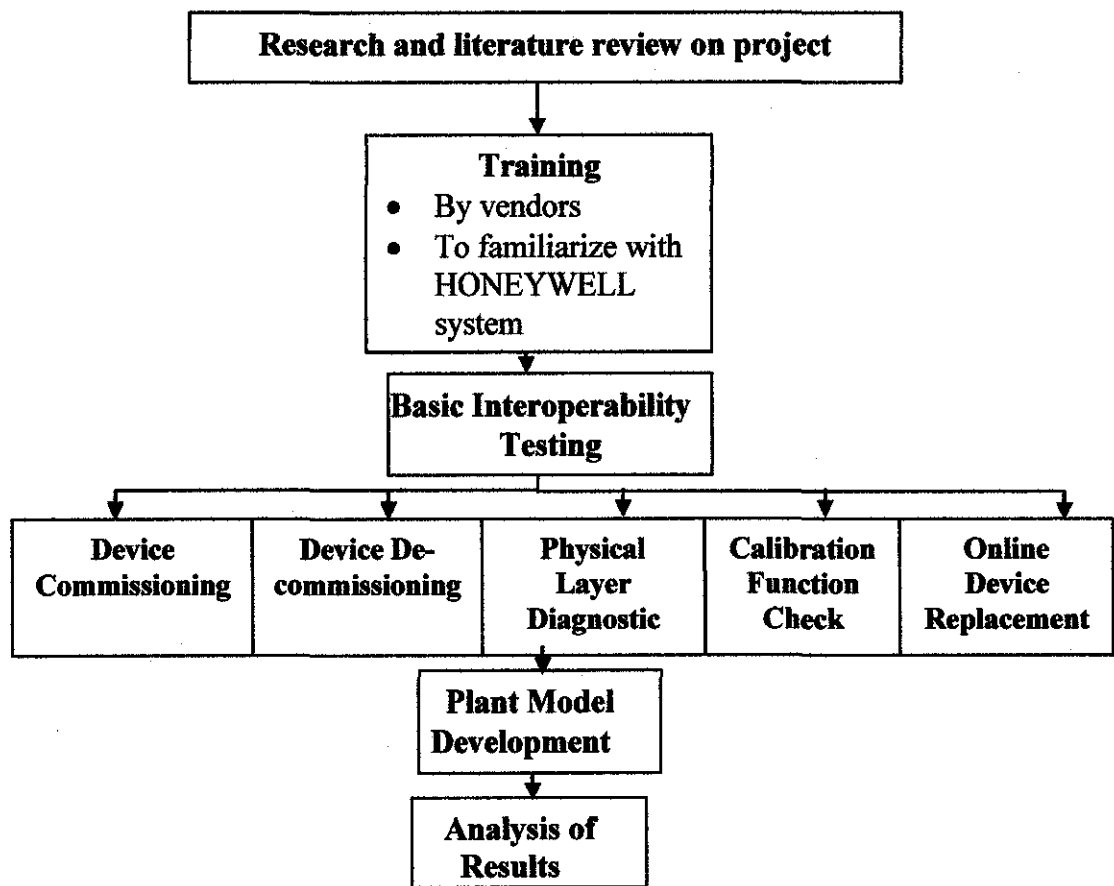
Currently Foundation Fieldbus is being installed and implemented by major companies and plants, such as NASA. Foundation Fieldbus is very efficient for usage in plants or companies due to its capabilities. Although the earlier instruments are inexpensive, but what is gained in savings is lost in accuracy, and it is subjected to electrical noise. Foundation Fieldbus transmitters are loop powered and require no extra signal conditioning. Perhaps one of the most important feature that encourages the companies to switch to Foundation Fieldbus is the amount of live data available for the diagnosis of problems or remote calibration.

# CHAPTER 3

## METHODOLOGY

### 3.1 Procedures Identification

The flow chart below shows the work flow to achieve the objectives of the project



**Figure 8: Project Work Flow**

The project mainly aims to build a Foundation Fieldbus interoperability test, which will be conducted through the period of the two semesters. For this project two tests were done which are, basic interoperability testing and stress test, For the mean time, the focus was on repeating the interoperability testing.

The basic test will cover five tests, to be done using the test bench of the foundation fieldbus. The test bench includes four hosts, 28 devices, high power trunk concept, and three cabinets. The five tests are Device Commissioning, Decommissioning, Online Device Replacement, Physical Layer Diagnostic and calibration Function Checks.

Device commissioning test shows how well the FF startup procedure of a completely new system works. Extra steps needed to make the system function. Accordingly, this gauges the difficulty level of commissioning of a FF system. The main part of the test is to see how well the host can download or retrieve information from the field devices.

In Device Decommissioning test is used for maintenance and also for replacement the new devices, At the end of the test, each of the devices must successfully decommission.

For Online Device Replacement test, it shows the effects of an unknown device being introduced into a FF system. Response of the host and other devices in the system are recorded. Replacement of known device but with a different revision number is also tested. This test is on how to see the behavior of the system when the new device is being placed in the system. In fact, there is no replacement for any new device but only, the device tag name is replaced using the 375 Field Communicator Device, then the system identifies it as a new device.

In physical Layer Diagnostic, there are several method can be used such as scaling using the parameters and also drop out cable method. If testing using parameters is applied, the 375 communicator is used to get the readings of the noise, voltage and also the current from each device. But for the drop out cable, the testing will only focus on the alarm after the cable has been pulled out.

Eventually, Calibration Function Check, this test is used to calibrate the device remotely using the HONEYWELL system or at the field site using the 375 Field Communicator Device. The test requires the team to come out with the guideline for operators on the calibration requirements, exceptional to Foundation Fieldbus devices and host, because calibrating Foundation Fieldbus devices is different from other devices.



### 3.2 Tools and equipments required

The equipments which are required for the Fieldbus Interoperability testing are as follows:

- Test Bench



**Figure 9: Test Bench with 28 devices**

- UTP Foundation Fieldbus consists of :
  - Four Hosts which are, HONEYWELL, YOKOGAWA, FOXBORO and EMERSON
  - Two segments, Segment 1 supplied by P+F and segment 2 supplied by MTL.
  - 28 devices and all are using High Power Trunk Concept.
  - Three Cabinets are utilized to house all the hosts and other monitoring/ diagnostic systems. Devices are placed on a separate

skid and for the moment are not connected to any process line.  
Workstations for the hosts are located in the same laboratory.



**Figure 10: Cabinets**

**Test Equipment:**

- Foundation Fieldbus Emerson 375 Communicator
- Multimeter
- 1 Amp Current Clamp meter
- Tool Set
- Multi Function Calibrator



**Figure 11: FF Emerson 375 Communicator**

## **CHAPTER 4**

### **RESULTS AND DISCUSSION**

#### **4.1 RESULTS**

##### ***4.1.1 Basic Interoperability Test Results***

Honeywell system is the host that supposed to be tested using the test bench provided in the lab at level 1, Building 23, University Technology PETRONAS. Basic Interoperability Testing was held after the system was repaired, since the last semester it was having some technical problems. The test was performed on HONEYWELL host and on Segment 2 provided by MTL.

The following tables [2]-[6] show the results of the five conducted. The procedures to conduct the tests are attached in Appendix 3.

**Table 2: Results for the device commissioning of Segment 2**

<b>No.</b>	<b>Device Name</b>	<b>Fully Download</b>	<b>Time Taken</b>
1	LT301	OK	<1 min
2	LT302	OK	<1 min
3	PT303	OK	<1 min
4	PDT304	OK	<1 min
5	AT305	-	-
6	FT306	OK	<1 min
7	FT101	-	-
8	TT401	OK	<1 min
9	TT308	-	-
10	PT402	OK	<1 min
11	PDT403	OK	<1 min
12	FV102	OK	<1 min

As shown in table 2, all of the devices were commissioned successfully except for FT101, AT305 and TT 308. They were in out of service mode.

**Table 3: Results for Device Decommissioning**

<b>No.</b>	<b>Device Name</b>	<b>Fully Download</b>	<b>Time Taken</b>
1	LT301	OK	1 min 25 sec
2	LT302	OK	1 min 12 sec
3	PT303	OK	3 min 35 sec
4	PDT304	OK	2 min 15 sec
5	AT305	-	-
6	FT306	OK	<1 min1 min 50 sec
7	FT101	-	-
8	TT401	OK	1 min 25 sec
9	TT308	-	-
10	PT402	OK	1 min 10 sec
11	PDT403	OK	2 min 20 sec
12	FV102	OK	1 min 12 sec

As shown in table 3, all devices were able to decommission and no problems occurred

**Table 4: Results for calibration Function Check**

<b>Device Name</b>	<b>Host Response</b>	<b>375 communicator response</b>
LT301	-	Error Occurred in 375 communicator. It stated that device upload aborted. Device unable to change the value of the scale
LT302	-	Error Occurred in 375 communicator. It stated that device upload aborted. Device unable to change the value of the scale
PT303	-	Error Occurred in 375 communicator. It stated that device upload aborted. Device unable to change the value of the scale
PDT304	-	Error Occurred in 375 communicator. It stated that device upload aborted. Device unable to change the value of the scale
AT305	Device in Offline Mood	-
FT306	At the AI function block, the range of the transducer scale (XD_scale) and the output scale (OUT_SCALE) is changed	The range of transducer scale (XD_SCALE) and the output scale (OUT_SCALE) is changed at 375 communicator
FT101	Device in Offline Mood	-

TT401	-	Error Occurred in 375 communicator. It stated that device upload aborted. Device unable to change the value of the scale
TT308	Device in Offline Mood	-
PT402	At the AI function block, the range of the transducer scale (XD_scale) and the output scale (OUT_SCALE) is changed	The range of transducer scale (XD_SCALE) and the output scale (OUT_SCALE) is changed at 375 communicator
PDT403	At the AI function block, the range of the transducer scale (XD_scale) and the output scale (OUT_SCALE) is changed	The range of transducer scale (XD_SCALE) and the output scale (OUT_SCALE) is changed at 375 communicator
FV102	-	Error Occurred in 375 communicator. It stated that device upload aborted. Device unable to change the value of the scale

As shown in table 4, Only Three Devices FT306, PT402, and PDT403, were able to complete the test successfully. When the device range for transducer scale (XD\_SCALE) and output scale (OUT\_SCALE) is changed using Host, the range at the field automatically changes, this can be observed by using 375 communicator device. Likewise, when the device range for transducer scale (XD\_SCALE) and output scale (OUT\_SCALE) is changed using 375 communicator device, the range at the host automatically changes, this can be observed on the AI function block.

But for PT303, FV102 and TT 401, the error reading mentioned that the device upload is aborted and the devices are unable to change the value of the scale.

For LT301, LT302 and PDT304, the error reading mentions that the system is unable to load Device Description file.

**Table 5: Results for Online Device Replacement**

<b>No.</b>	<b>Device Name</b>	<b>Time Taken</b>	<b>Successful</b>
1	LT301	4 min 20 sec	YES
2	LT302	3 min 50 sec	YES
3	PT303	10 min 20 sec	YES
4	PDT304	7 min 45 sec	YES
5	AT305	-	-
6	FT306	9 min 35 sec	YES
7	FT101	-	-
8	TT401	8 min 45 sec	YES
9	TT308	-	-
10	PT402	3 min 40 sec	YES
11	PDT403	2 min 20 sec	YES
12	FV102	4 min 15 sec	YES

As shown above, all the devices were successfully replaced, when a device is taken out of the field it turns red at the control builder but the device turns back green again, after the device is replaced.



**Table 6: Results for Physical Layer Diagnostic**

Device Name	Drop-Out Response
LT301	<p><b><u>Initial Condition:</u></b></p> <p>At the control Builder, the device is displayed in green color</p> <p><b><u>Drop-Out Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, the Device is in Red Color</li> <li>• Station. Alarm displayed</li> </ul> <p><b><u>Plug-In Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, device turns to Green color</li> <li>• Station, Alarm Display Gone</li> </ul>
LT302	<p><b><u>Initial Condition:</u></b></p> <p>At the control Builder, the device is displayed in green color</p> <p><b><u>Drop-Out Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, the Device is in Red Color</li> <li>• Station. Alarm displayed</li> </ul> <p><b><u>Plug-In Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, device turns to Green color</li> </ul> <p>Station, Alarm Display Gone</p>
PT303	<p><b><u>Initial Condition:</u></b></p> <p>At the control Builder, the device is displayed in green color</p> <p><b><u>Drop-Out Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, the Device is in Red Color</li> <li>• Station. Alarm displayed</li> </ul> <p><b><u>Plug-In Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, device turns to Green color</li> </ul>

	Station, Alarm Display Gone
PDT304	<p><b><u>Initial Condition:</u></b></p> <p>At the control Builder, the device is displayed in green color</p> <p><b><u>Drop-Out Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, the Device is in Red Color</li> <li>• Station. Alarm displayed</li> </ul> <p><b><u>Plug-In Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, device turns to Green color</li> </ul> <p>Station, Alarm Display Gone</p>
FT306	<p><b><u>Initial Condition:</u></b></p> <p>At the control Builder, the device is displayed in green color</p> <p><b><u>Drop-Out Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, the Device is in Red Color</li> <li>• Station. Alarm displayed</li> </ul> <p><b><u>Plug-In Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, device turns to Green color</li> </ul> <p>Station, Alarm Display Gone</p>
TT401	<p><b><u>Initial Condition:</u></b></p> <p>At the control Builder, the device is displayed in green color</p> <p><b><u>Drop-Out Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, the Device is in Red Color</li> <li>• Station. Alarm displayed</li> </ul> <p><b><u>Plug-In Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, device turns to Green color</li> </ul> <p>Station, Alarm Display Gone</p>

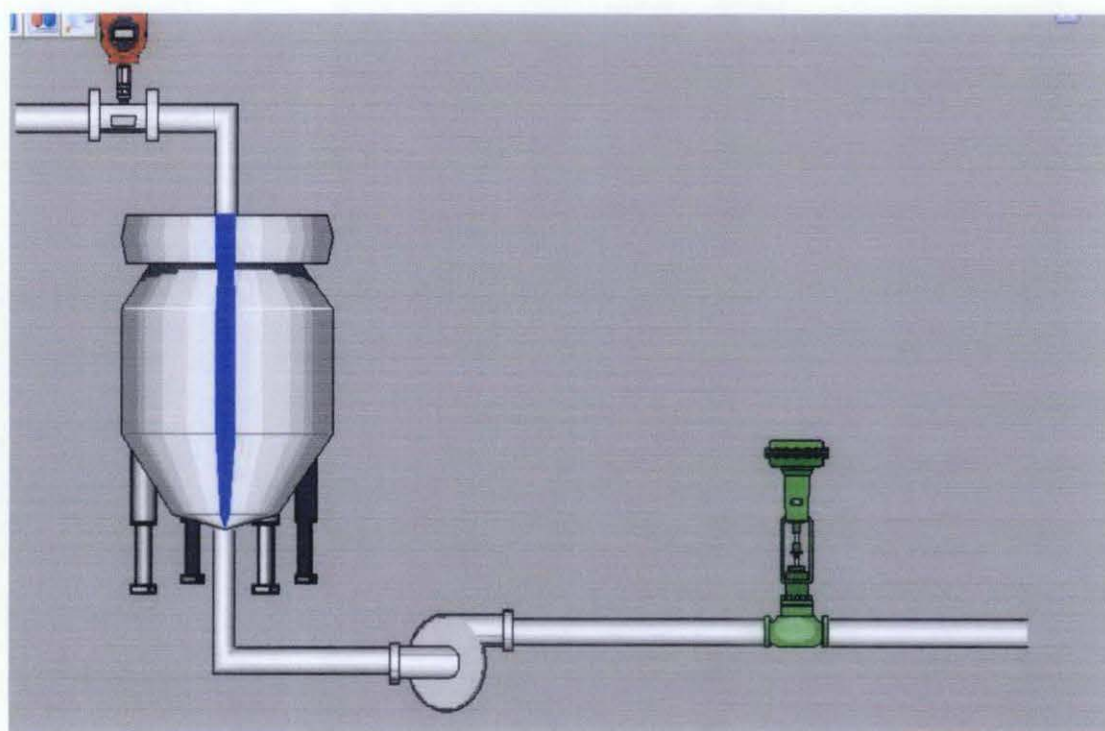
PT402	<p><b><u>Initial Condition:</u></b></p> <p>At the control Builder, the device is displayed in green color</p> <p><b><u>Drop-Out Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, the Device is in Red Color</li> <li>• Station. Alarm displayed</li> </ul> <p><b><u>Plug-In Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, device turns to Green color</li> </ul> <p>Station, Alarm Display Gone</p>
PDT403	<p><b><u>Initial Condition:</u></b></p> <p>At the control Builder, the device is displayed in green color</p> <p><b><u>Drop-Out Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, the Device is in Red Color</li> <li>• Station. Alarm displayed</li> </ul> <p><b><u>Plug-In Device:</u></b></p> <ul style="list-style-type: none"> <li>• Control Builder, device turns to Green color</li> </ul> <p>Station, Alarm Display Gone</p>

As shown in table 6, the purpose of this test is to test the two way communication from device to the host and vice versa. All devices were successfully done and no problem occurred during the testing

### 4.1.2 Plant Design

To test on the control performance of the system, a simple control loop was developed, Figure [12] shows the Design of the plant. The figure was designed using Emerson DELTA V system but will be implemented on Honeywell Host.

A Transmitter and a Valve were chosen **FT 504, FV205**. The transmitter will be used as the analog input, and the Analog Output will be the Valve

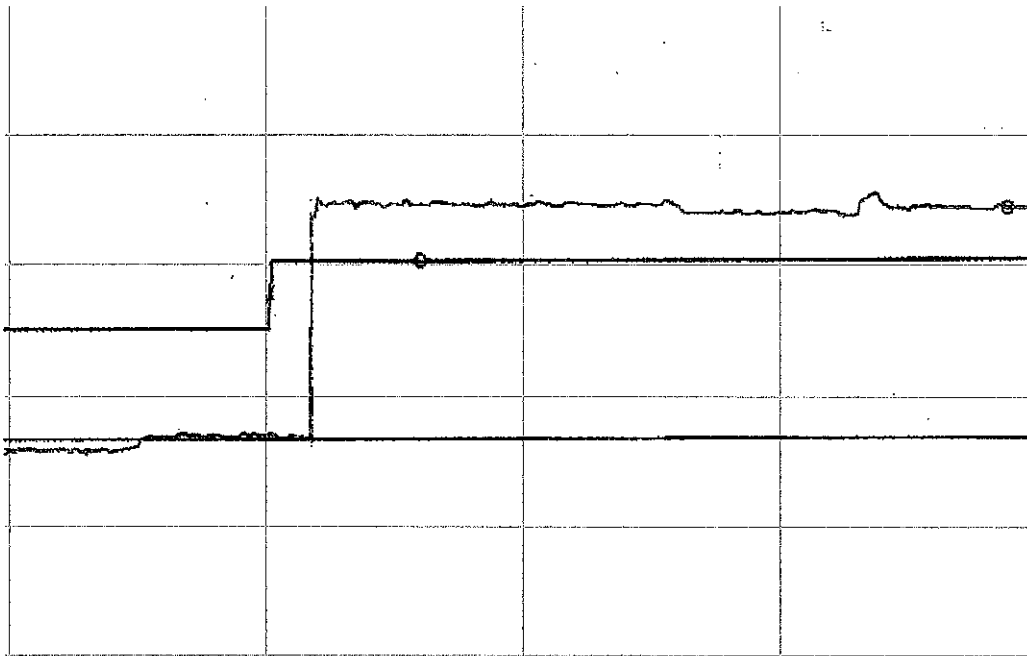


**Figure 12: Crude Oil Plant where the Flow of the oil is being monitored**

The plant configuration pictures are attached in the Appendix 1. To give a clearer picture on the model. Analogue Input Block is used, this block is mainly the input which is taken from the transmitter, DACA block stands for data acquisition block which is used for alarm triggering, PIDA block is used for the PID trends and monitoring the controller performance using the trends given, AO stands for analogue

output function block and it's used to execute the output, usually it's taken from the valve.

In this plant model, the process variable (PV) is the flow measured by the transmitter FT504 ( $\text{m}^3/\text{h}$ ). The manipulated variable is represented by the percentage of the opening of the control valve FY-205. According to the below Process Reaction Curve, it's a first order process reaction curve with dead time.



**Figure 13: Process Reaction Curve**

The set point was at  $2.00 \text{ m}^3/\text{h}$ , the data in table [7] shows the results taken from the Process Reaction Curve (PRC).

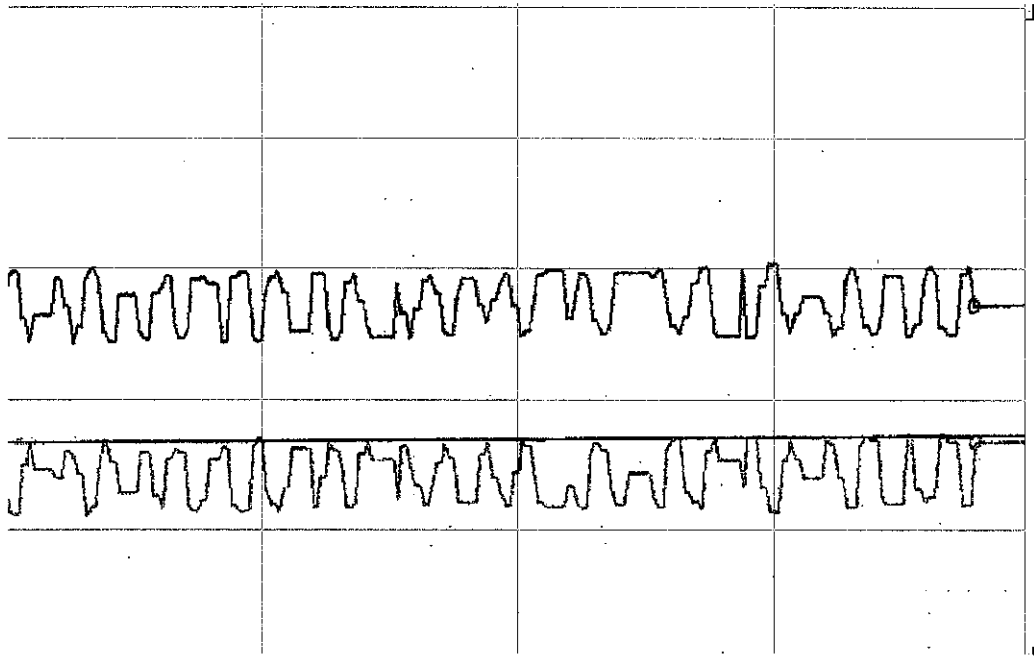
**Table 7: Process Reaction Curve Results**

Measurement	Value
Change in Perturbation/MV, $\sigma$	10%
Change in output/PV, $\Delta$	0.58 m <sup>3</sup> /h
Maximum Slope, S	0.0928 m <sup>3</sup> /h/s
Dead Time, $\Theta$	29S
Calculation	Value
$K_p = \Delta/\sigma$ , Process Gain	0.058 m <sup>3</sup> /h
$T = \Delta/S$ , Time Constant	0.58/0.0928=6.25
$R = \Theta/T$ , Fraction Dead Time	25/6.25=4

Closed loop method was used using Ziegler-Nichols Closed Loop Method; the graph of the closed loop is below. The method was used in order to find the Ultimate Gain  $K_u$  and Ultimate Time  $P_u$ . So that they can be used to tune the controller.

From the obtained results, the transfer function is as follows:

$$T.F = Y(S) / X(S) \rightarrow 0.058 e^{-29} / 6.25S+1$$



**Figure 14: Closed Loop Tunning**

After analyzing Figure [14], the following results are obtained, as shown in table [8]

**Table 8: Closed Loop Tuning Results**

Measurement	Value
Ultimate Gain $K_u$	16 m <sup>3</sup> /h
Time for 3 oscillations	29.27S
Calculation	Value
Ultimate Time $P_u$	9.75S

**Table 9: Ziegler Nichols Closed Loop Correlations**

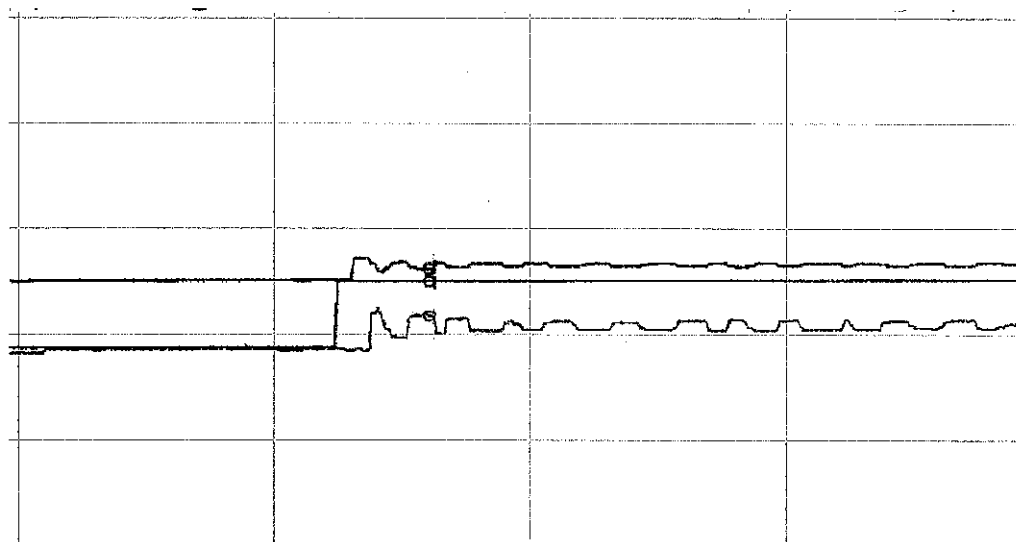
Control Modes	$K_c$	$T_I$	$T_D$
P	$0.5K_u$	-	-
PI	$0.45K_u$	$P_u/1.2$	-
PID	$0.6K_u$	$P_u/2$	$P_u/8$

After substituting the values from table 8 into table 9, we get the PID controller parameters, which are mentioned below in the table. For each controller mode we set the certain values to get the P, PI and PID graphs.

**Table 10: PID Controller Parameters**

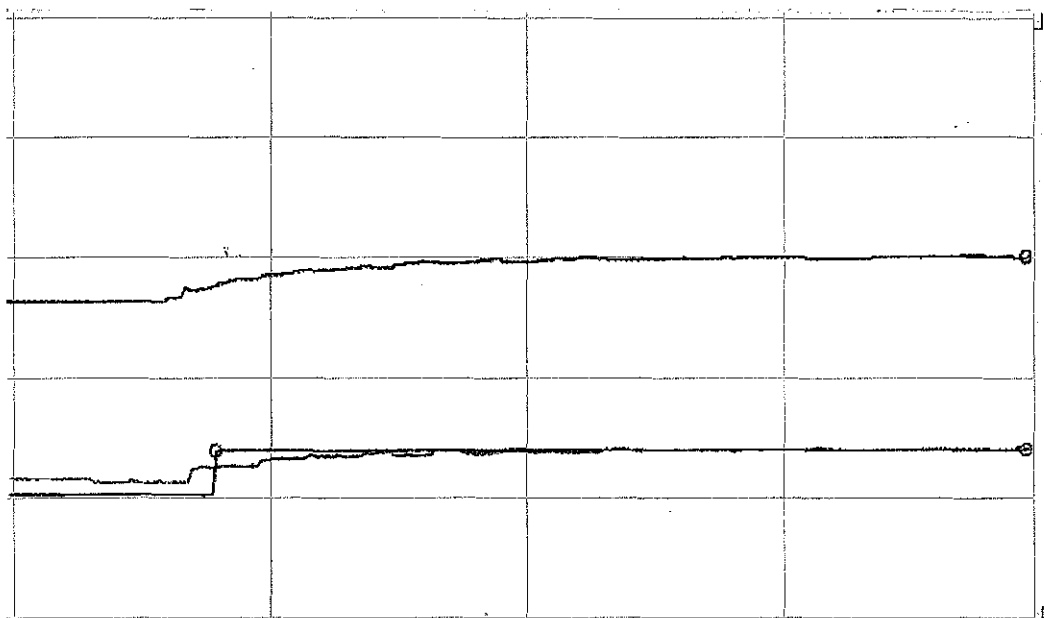
Tuning Parameters	P	PI	PID
<b>K<sub>c</sub></b> , Gain	8	7.2	9.6
<b>T<sub>I</sub></b> , Integral Time	-	8.12	4.87
<b>T<sub>D</sub></b> , Derivative Time	-	-	1.22





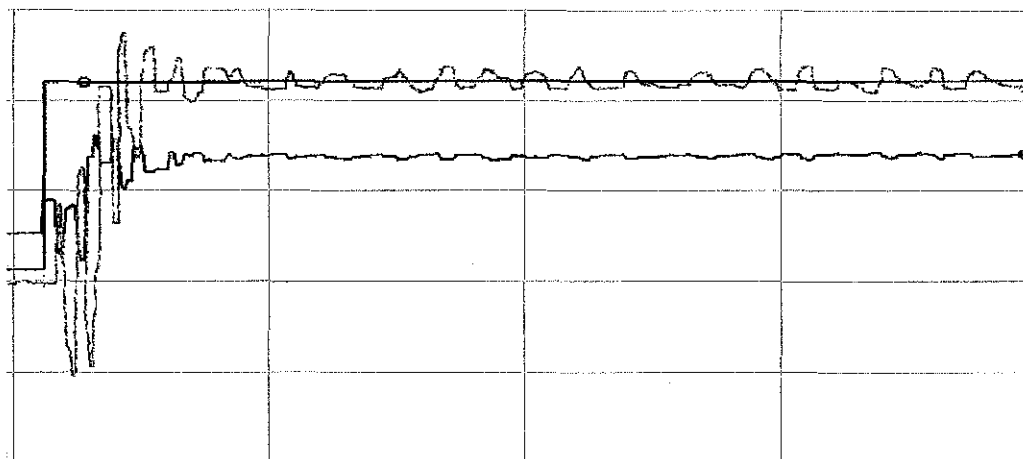
**Figure 15: Performance of P controller**

As shown in figure (15), as well as the data of performance (table 11), the system is un damped response. The system has taken a long period to settle to steady state. This is undesired for flow process. The problem that faced this controller mode is a non zero offset ( $0.28 \text{ m}^3/\text{h}$ ). Rise Time in P mode is very short compared with its settling time. In addition, the overshoot percentage is 22.09%, which is not that affirmative but still acceptable as well as the decay ratio. In general the P-mode isn't desired.



**Figure 16: Performance of PI controller**

As shown in figure (16) as well as the data of performance (table 11), the system shows a zero offset, a low decay ratio, same rise time as P-mode, a longer settling time, and a very small percentage overshoot. The PI mode has eliminated the non-zero offset problem occurred in P-mode. So the PI controller has controlled the system in an acceptable and desired response



**Figure 17: Performance of PID controller**

As shown in figure (17) as well as the data of performance (table 11), the system shows an unstable response, the offset is oscillating. There are two problems occurred in PID, high frequency noise in PV and extreme variation in MV. So, PID controller isn't desired and not suitable for this control loop

**Table 11: Pefromance measures for PID Controllers**

Performance	P	PI	PID
<b>System Response</b>	Un damped	Under damped	Unstable
<b>Offset, Final steady state of CV</b>	0.28 m <sup>3</sup> /h	0	Oscillating
<b>Decay Ratio</b>	1.12	0.98	No decay
<b>Rise Time</b>	2 seconds	2.4 seconds	2 seconds
<b>Settling Time</b>	70 seconds	110 seconds	Oscillating
<b>Percentage of Overshoot</b>	22.09%	2%	Oscillating

## **4.2 DISCUSSION**

This project involves host from four different vendors: Emerson, Foxboro, Yokogawa and Honeywell. For this specific project, Honeywell host will be tested. The focus in this project is on Segment 2 provided by MTL.

The plant uses high power trunk concept which contains two segments: Segment 1 holds 14 devices and Segment 2 which holds 13 devices. The topology used is Chicken foot topology which is allowed by PETRONAS.

The controller performance was successfully tested, graphs and results were obtained and analyzed.

## **CHAPTER 5**

### **CONCLUSION AND RECOMMENDATIONS**

#### **5.1 CONCLUSION**

With the advantages of the Fieldbus technology, PETRONAS the operating company will make a step forward in upgrading their system. Overall the project achieved the main objectives which are, to come out with a report from interoperability testing which will be used as a reference for Foundation Fieldbus system in PETRONAS and the other objective which is testing the controller performance using different modes, P, PI and PID. Basic interoperability testing was done successfully on Segment 2 using HONEYWELL system. Foundation Fieldbus is a new experience but it offers many advantages to engineering companies. Successful planning and execution of process control projects will result in achieving maximum technical and economic benefit.

#### **5.2 RECOMMENDATIONS**

The system supplied should give detailed training about their system, since some difficulties were faced during the testing. Personnel from the supplier company should join the testing to assist the team using the system.

PI controller showed the best performance, so for further operations PI mode is recommended, however PID can also show good results but requires more tuning which can be held by the next UTP team in charge of this project.

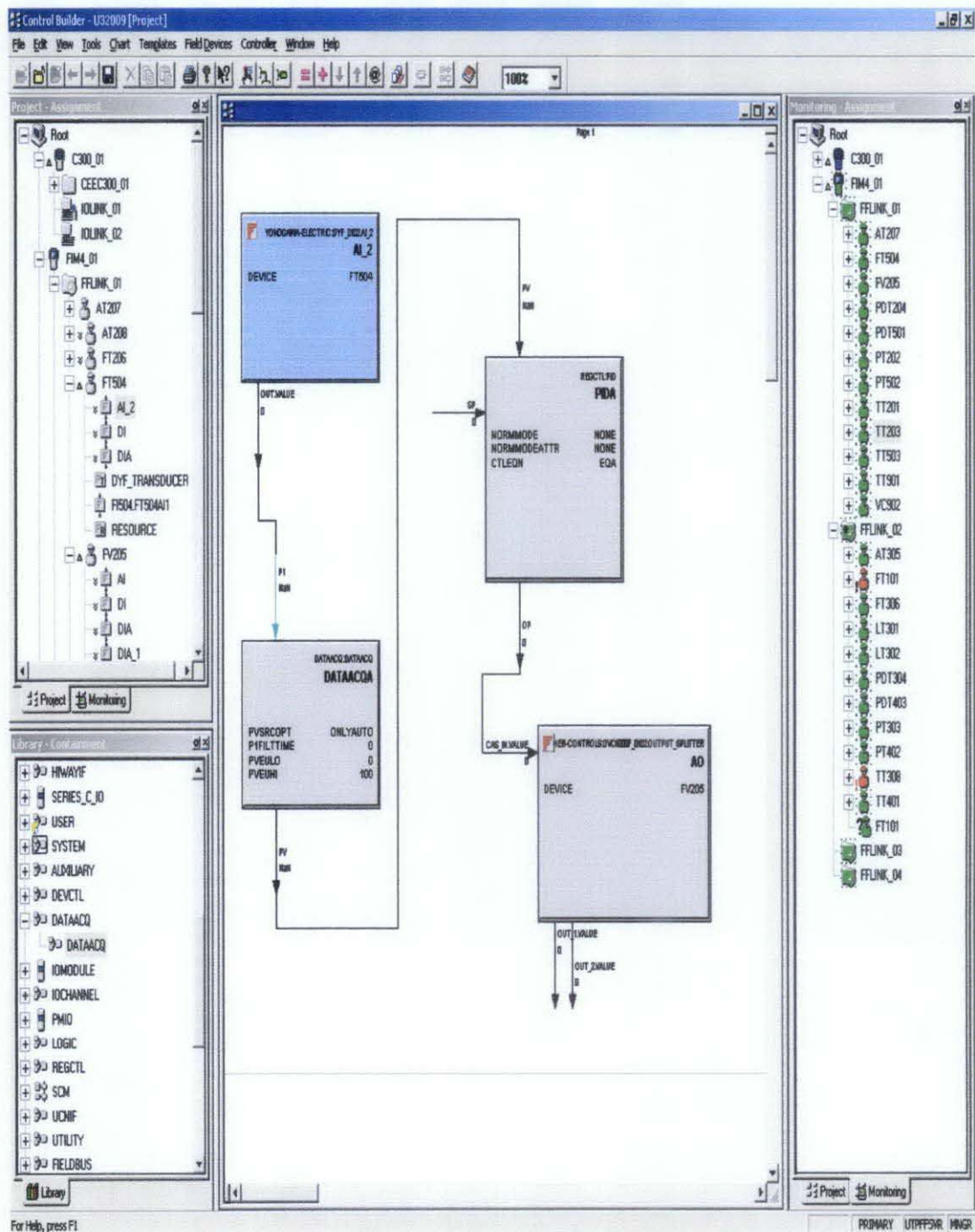
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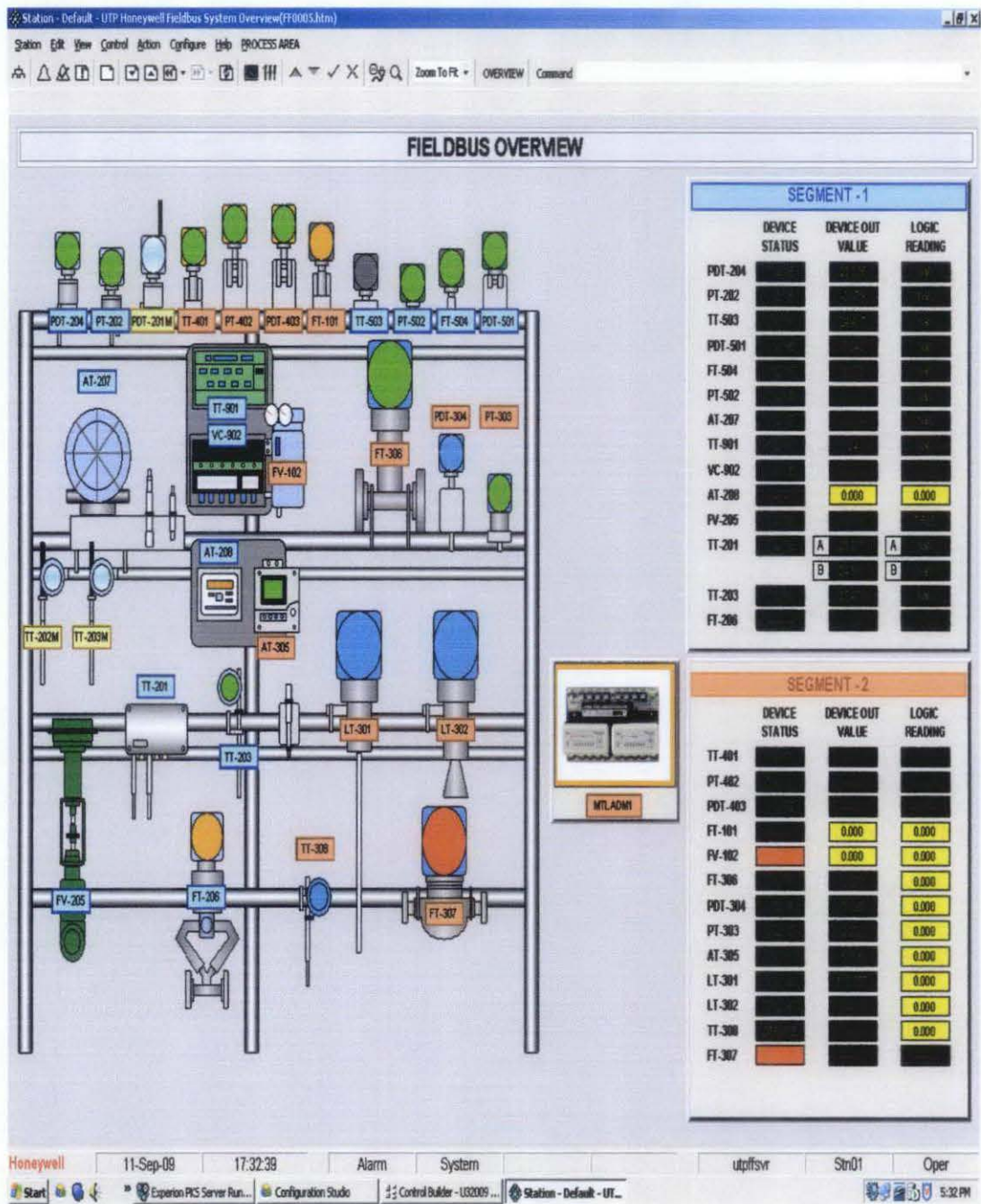
## **APPENDICES**



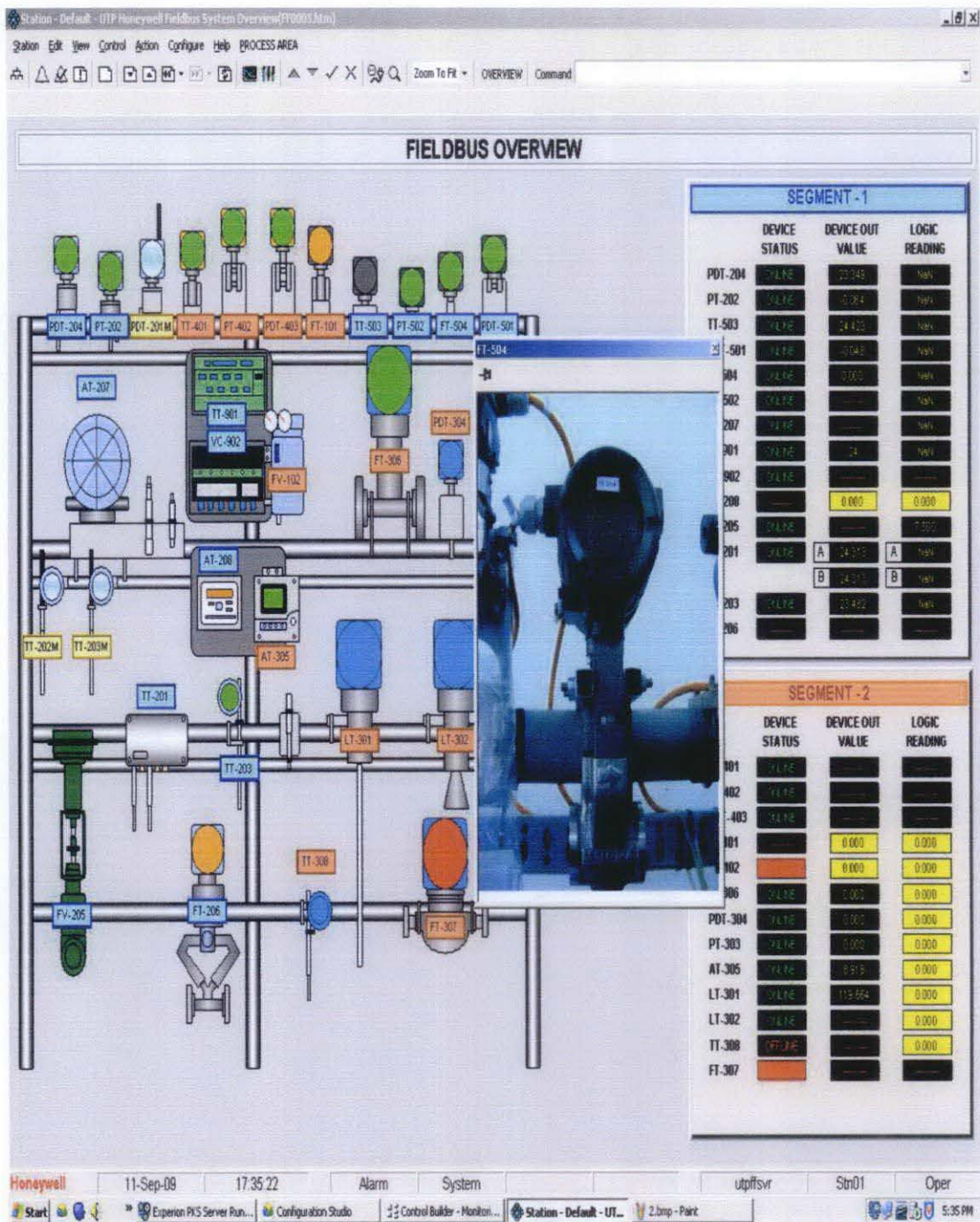
APPENDIX 1



Appendix 2







## **APPENDIX 3**

### **Procedures for Doing the Basic Interoperability Test**

#### **1.0 DESCRIPTION**

##### **1.1 *Device Commissioning – Initial Download***

- 1.1.1 Power up Host system at Cabinet 3.
- 1.1.2 Power up switch for MTL and P+F at Cabinet 2.
- 1.1.3 At the selector switch (front panel of Cabinet 2), select Honeywell for Segment 1 and Segment 2.
- 1.1.4 Click "Start"
- 1.1.5 Select "Programs"
- 1.1.6 Select "Honeywell Experion PKS"
- 1.1.7 Select "Configuration Studio"
- 1.1.8 Connect window will popup , select "UTPFFSystem" ,click "Connect"
- 1.1.9 Login to windows using the following username and password:
  - Username: mngr
  - Password: mngr1
  - Domain: <Traditional Operator Security>
- 1.1.10 Click OK.
- 1.1.11 Expand "UTPFFSystem"
- 1.1.12 Expand "Server"
- 1.1.13 Expand "UTPFFSVR"
- 1.1.14 Click "Control Strategy"

1.1.15 From "Process Control Strategy", click "Configure Process Control Strategies" and a "Control Builder" window will popup

1.1.16 At "Monitoring – Assignment", check the status of C300\_01 and FIM4\_01.

*Note: Both should be in GREEN colour. In case of Controller in offline state for more than 120hours, the program needs to be restored. The state is marked by RED colour.*

1.1.17 If at RED,

1.1.17.1 Right Click at "C300\_01"

1.1.17.2 Select "Checkpoint"

1.1.17.3 Select "Restore from checkpoint".

1.1.17.4 A new window will pop up.

1.1.17.5 Select the last saved checkpoint to be restored.

1.1.17.6 Click "Restore"

1.1.17.7 Start the controller by double clicking on controller "CEEC300\_01".

1.1.17.8 At "Main" tab, go to "CEE Command," and select WARMSTART. Click YES. Wait until all the icons turns Green.

1.1.18 From the "Monitoring-Assignment",

1.1.18.1 Expand "FIM4\_01"

1.1.18.2 Expand "FFLINK\_01" (the segment)

1.1.18.3 Check the status of the device base on the colour/ '?' sign.

RED : Already in the database but the system cannot detect

BLUE: Idle / Inactive

GREEN : Live device

'?' sign : Uncommissioned device

1.1.18.4 Double click on the device with the '?' sign.

- 1.1.18.5 A window will be popup and select the device name.
  - 1.1.18.6 Click "Commission Device Without Pre-Configuration" ( Note: Take from device to segment), "User Authorisation" window will be popup, click "NEXT" until complete
  - 1.1.18.7 Commissioning is successful when device turns GREEN.
  - 1.1.18.8 Repeat steps for other devices.
- 1.1.19 If the device is unable to commission (device GREEN colour with '?' sign only)
- 1.1.19.1 At "Project-Assignment"
    - 10.1.19.1.1 Expand "FIM4\_01"
    - 10.1.19.1.2 Expand "FFLINK\_01"
    - 10.1.19.1.3 Select device
    - 10.1.19.1.4 Right click
    - 10.1.19.1.5 Select "Load"
    - 10.1.19.1.6 Click "Continue"
    - 10.1.19.1.7 Click OK

*Note: Check the 'Automatically change ALL control elements to the state selected in 'Post Load State' after load is completed'*
  - 1.1.19.2 At "Project-Assignment",
    - 10.1.19.2.1 Expand "CEEC300\_01"
    - 10.1.19.2.2 Select function block of the device
    - 10.1.19.2.3 Right click
    - 10.1.19.2.4 Select "Load"
    - 10.1.19.2.5 Click "Continue"
    - 10.1.19.2.6 Click OK

*Note: Check the 'Automatically change ALL control elements to the state selected in 'Post Load State' after load is completed'*

1.1.19.3 At "Monitoring-Assignment", device turn to GREEN without '?' sign.

10.1.20 If the device unable to commission (device has two same tag ; 1 GREEN colour with '?' sign , and the other tag RED colour)

10.1.20.1 At "Monitoring-Assignment" (at the bottom of the window),

10.1.20.1.1 Expand the "CEEC300\_01"

10.1.20.1.2 Select the function block of device

10.1.20.1.3 Right click

10.1.20.1.4 Select "Inactivate"

10.1.20.1.5 Select "Selected item(s) and Content(s)"

10.1.20.1.6 A window will popup, click YES

10.1.20.1.7 Wait for seconds until the device tag turn to BLUE (Idle state)

10.1.20.2 At "Monitoring-Assignment",

10.1.20.2.1 Expand "CEEC300\_01"

10.1.20.2.2 Select the BLUE device

10.1.20.2.3 Right click

10.1.20.2.4 Select "Force Delete"

10.1.20.2.5 BLUE device will be deleted

10.1.20.3 At "Monitoring-Assignment",

10.1.20.3.1 Expand "FIM4\_01"

10.1.20.3.2 Expand "FFLINK\_01"

10.1.20.3.3 Select RED device tag

10.1.20.3.4 Right click

- 10.1.20.3.5 Select "Force Delete"
- 10.1.20.3.6 A window will popup, click "Continue"
- 10.1.20.3.7 Click "Force Delete"
- 10.1.20.3.8 RED device will be deleted

10.1.20.4 At Project-Assignment",

- 10.1.20.6.10 Expand "FIM4\_01"
- 10.1.20.6.11 Expand "FFLINK\_01"
- 10.1.20.6.12 Select device tag (device that need to be commission)
- 10.1.20.6.13 Right click
- 10.1.20.6.14 Select "Load"
- 10.1.20.6.15 Click "Continue"
- 10.1.20.6.16 Click OK

*Note: Check the 'Automatically change ALL control elements to the state selected in 'Post Load State' after load is completed'*

10.1.20.5 Open "Monitoring", the device tag should turn to GREEN (already commissioned)

10.1.20.6 At Project-Assignment",

- 10.1.20.6.1 Expand "CEEC300\_01"
- 10.1.20.6.2 Select function block of device
- 10.1.20.6.3 Right click
- 10.1.20.6.4 Select "Load"
- 10.1.20.6.5 Click "Continue"
- 10.1.20.6.6 Click OK

*Note: Check the 'Automatically change ALL control elements to the state selected in 'Post Load State' after load is completed'*

10.1.20.7 Commission of the device succeed.



- 10.1.21 If there is no loop of the device at CEEC300\_01, create the loop for the device
  - 10.1.21.1 Open the "Control Builder" window
  - 10.1.21.2 At "Project-Assignment",
    - 10.1.21.4.10 Expand "CEEC300\_01"
    - 10.1.21.4.11 Select any device ( Note: Require to choose other device in order to copy the connection between AI block and DACA block)
    - 10.1.21.4.12 Right click
    - 10.1.21.4.13 Select "Copy"
    - 10.1.21.4.14 "Name New Function Block(s)" window will popup
    - 10.1.21.4.15 Change the destination for the "Tag Names" and "Items Names", with the device's loop that need to be create
    - 10.1.21.4.16 Click "Finish"
  - 10.1.21.3 At "Project-Assignment",
    - 10.1.21.3.1 Expand "Unassigned"
    - 10.1.21.3.2 New loop will be created in the "Unassigned"
    - 10.1.21.3.3 Click and drag the new loop from Unassigned to "CEEC300\_01"
    - 10.1.21.3.4 Expand "CEEC300\_01"
    - 10.1.21.3.5 Double click the new loop. AI block and DACA block will be appeared.
    - 10.1.21.3.6 Delete the AI block (Note: Since it is the copy of the other device's AI block)
  - 10.1.21.4 At "Project-Assignment",
    - 10.1.21.4.1 Expand "CEEC300\_01"

- 10.1.21.4.2 Expand new loop
- 10.1.21.4.3 Search the AI of the device loop
- 10.1.21.4.4 Click drag the AI in the new loop into the "Project" window
- 10.1.21.4.5 Connect OUTVALUE of the AI block to the input of the DACA block ( double click at the OUTVALUE arrow, then single click to the DACA block)
- 10.1.21.4.6 Click "Save"

10.1.21.5 At "Project-Assignment",

- 10.1.21.5.1 Expand "CEEC300\_01"
- 10.1.21.5.2 Expand new loop
- 10.1.21.5.3 Right click
- 10.1.21.5.4 Select "Load"
- 10.1.21.5.5 A window will popup and click "Continue"
- 10.1.21.5.6 Click OK

*Note: Check the 'Automatically change ALL control elements to the state selected in 'Post Load State' after load is completed'*

10.1.21.6 At "Monitoring-Assignment", new loop will be create successfully in "CEEC300\_01"

## 1.2 Device Decommissioning

1.2.1 From "Monitoring-Assignment",

- 10.2.1.1 Expand "FIM4\_01"
- 10.2.1.2 Expand "FFLINK\_01" (segment 1)
- 10.2.1.3 Check the status of the device base on the colour/ '?' sign.

RED: already in the database but the system  
cannot be read      BLUE: Idle / Inactivate  
GREEN: Live  
'?' sign: uncommissioned device

- 1.2.2      From "Monitoring-Assignment",
- 10.2.2.1    Expand "CEEC300\_01"
  - 10.2.2.2    Select function block of the device
  - 10.2.2.3    Right click
  - 10.2.2.4    Select "Inactivate"
  - 10.2.2.5    Select "Selected item(s)"
  - 10.2.2.6    Click YES
  - 10.2.2.7    Device will turned to BLUE
  - 10.2.2.8    Right click at the BLUE function block
  - 10.2.2.9    Select "Delete"
  - 10.2.2.10   A window will popup, and click "Continue"
  - 10.2.2.11   Click " Delete Selected Object(s)"
  - 10.2.2.12   Function block been deleted
- 1.2.3      At "Monitoring-Assignment",
- 10.2.3.1    Expand "FIM4\_01"
  - 10.2.3.2    Expand "FFLINK\_01"
  - 10.2.3.3    Select device tag
  - 10.2.3.4    Right click
  - 10.2.3.5    Select "Force Delete"
  - 10.2.3.6    "Force Delete: window will popup
  - 10.2.3.7    Click "Continue"
  - 10.2.3.8    Click "Force Delete"
- 1.2.4      Device will GREEN and with '?' sign. It shows device  
decommission successfully

### **10.3 Online Device Replacement**

- 10.3.1 At "Monitoring-Assignment", select the device that need to be replaced
- 10.3.2 Click "Field Devices" (located at top of the window)
  - 10.3.2.1 Select "Device Replacement"
  - 10.3.2.2 Device Replacement Wizard window will popup
  - 10.3.2.3 Click NEXT
  - 10.3.2.4 Click "Yes,Upload"
  - 10.3.2.5 FF Device Replacement Wizard window will popup
  - 10.3.2.6 Wait for the device that need to be replaced been detected by the system
- 10.3.3 At field site, the old device need to be disconnect and replace with the new device (For the testing: we replaced with the same device but with the new tag name and new address using 375 Field Communicator Device)
  - 10.3.3.1 Using 375 Field Communicator Device, connect the cable to the Fieldbus Port and Press 'On' button
  - 10.3.3.2 Select "Fieldbus Application"
  - 10.3.3.3 Select "Online". (Note: The communicator will upload information on all devices connected to the segment.)
  - 10.3.3.4 Select the device
  - 10.3.3.5 Double click at the device
  - 10.3.3.6 Select "Details"
  - 10.3.3.7 Select "Physical Device Tag "
  - 10.3.3.8 Change the tag name of the device
  - 10.3.3.9 Click OK
  - 10.3.3.10 Click "Send"

- 10.3.3.11 Click YES and wait for the changes to be completed
- 10.3.4 At "Uncommissioned Replacement Device", tick (√) at the new device that will be replace. Uncheck and check again in order for a box will be popup at the bottom of the box.
- 10.3.5 Click "Replace the Failed Device with the Uncommissioned Replacement Device"
- 10.3.6 "FF Device Replacement Wizard- Verifying Replacement Device" window will pop up
- 10.3.7 Click "Continue"
- 10.3.8 Click OK
- Note: Check for "Automatically change ALL highlighted control elements to INACTIVE/OUT\_OF\_SERVICE before load" and "Automatically change ALL control elements to the state selected in "Post Load State" after load is completed"*
- 10.3.9 Click "Continue" and wait for the process
- 10.3.10 Click "Finish"
- 10.3.11 Device turn to GREEN and been commissioned as new device

#### **10.4 Physical Layer Inspection**

- 10.4.1 Using fieldbus communicator (375 Field Communicator):
  - 10.4.1.1 Connect the cable to the Fieldbus Port (Ensure Fieldbus logo can be seen)
  - 10.4.1.2 Press "On" button.
- 10.4.2 Identify terminator at the last field barrier. Connect the communicator to the terminal. Ensure the polarity is correct (red is positive, black is negative). The communicator will inform if the cable is not connected properly
- 10.4.3 On the communicator screen, select Foundation Fieldbus Application.

- 10.4.4 Select Fieldbus Diagnostic. The screen will show DC Voltage, noise and signal level.
- 10.4.5 Select "Start" and then select "OK". The screen will now show the mentioned diagnostic features. Ensure all values are within acceptable region by selecting on the parameter and select "Help"
- 10.4.6 Terminator:
- 10.4.6.1 Segment 1 is now connected to two terminators
  - 10.4.6.2 Record all the readings (DC voltage, low frequency noise, signal level of each device)
  - 10.4.6.3 Switch on another terminator. The segment is now connected to three terminators
  - 10.4.6.4 Record all readings
  - 10.4.6.5 Repeat the step 10.5.6.3 and 10.5.6.4 until have the maximum of 6 terminals.
  - 10.4.6.6 Repeat step 10.5.6.1 to 10.5.6.6. for segment 2.
  - 10.4.6.7 At the end of the test, connect the segments back to two terminators only
- 10.4.7 Practice the device drop out testing
- 10.4.8 At the field site, disconnect a device
- 10.4.9 Open the Station window, click the "System" (at the bottom of the window in SYSTEM box)
- 10.4.10 Device alarm appear on the screen and blinking
- 10.4.11 Click "Acknowledge Page" button to acknowledge the alarm.  
Alarm will stop blinking
- 10.4.12 Open the Control Builder window, at the "Monitoring-Assignment" window, monitor the status of the device  
*Note: Before disconnect the device, device in GREEN. After disconnect the device, device turn to RED*
- 10.4.13 At field site, connect device
- 10.4.14 At Station window, the device alarm will be gone

10.4.15            At Control Builder window, the device turn to GREEN

## **10.5    Calibration Function Checks**

Carry out calibration function from the Host, 375 communicator or iAMS.

### **10.5.1            Using Host:**

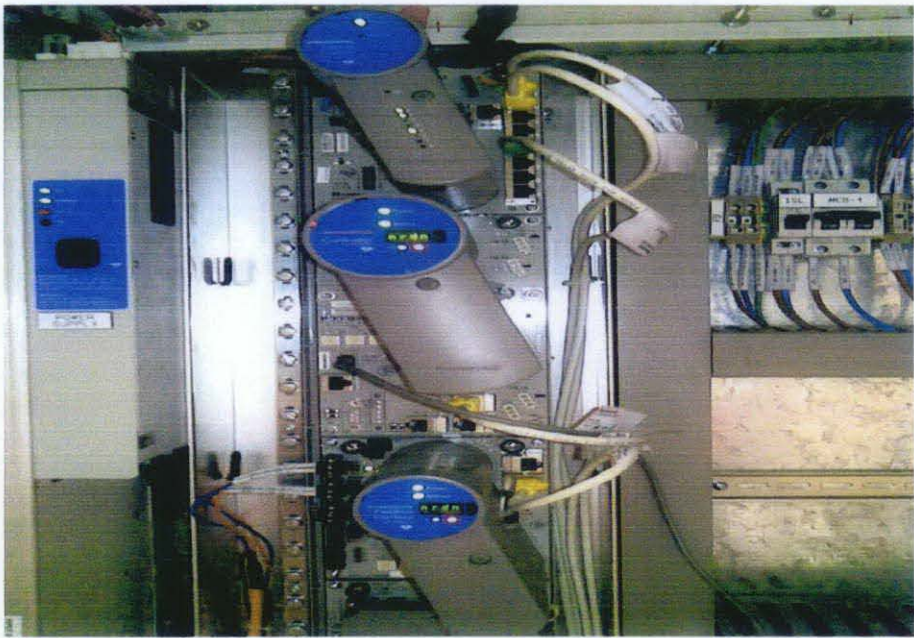
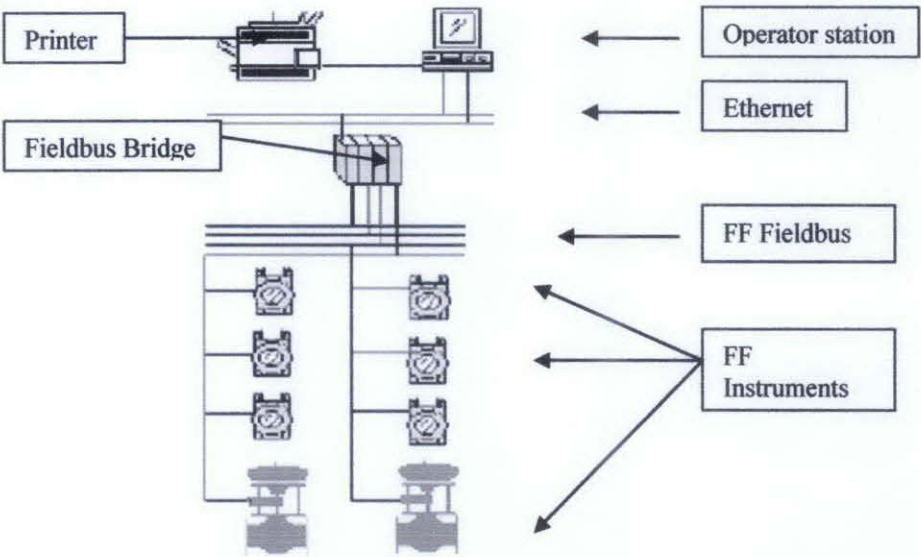
- 10.5.1.1            Type the name of the function block of the device at Command box
- 10.5.1.2            Click the details of the device (magnifying glass icon)
- 10.5.1.3            Data Acquisition Point Detail window will popup
- 10.5.1.4            Change system in "Engr" mode  
*Note: At the bottom right of the window; Password: engr*
- 10.5.1.5            Click "Main", change the Execution State to "Inactive"
- 10.5.1.6            Change to "Chart" window, AI block and DACA block will appeared.
- 10.5.1.7            Double click at DACA block
- 10.5.1.8            "Parameters[Monitoring]" will popup
- 10.5.1.9            Change the value for "PVEU Range Hi" and "PVEU Range Lo"
- 10.5.1.10           Close the "Parameters[Monitoring]" window
- 10.5.1.11           At "Main", change the Execution State to "Activate"
- 10.5.1.12           Monitor at the faceplate. Range for the faceplate will be change according to the previous changes
- 10.5.1.13           Double click at the AI Block
- 10.5.1.14           "Parameter[monitoring] popup

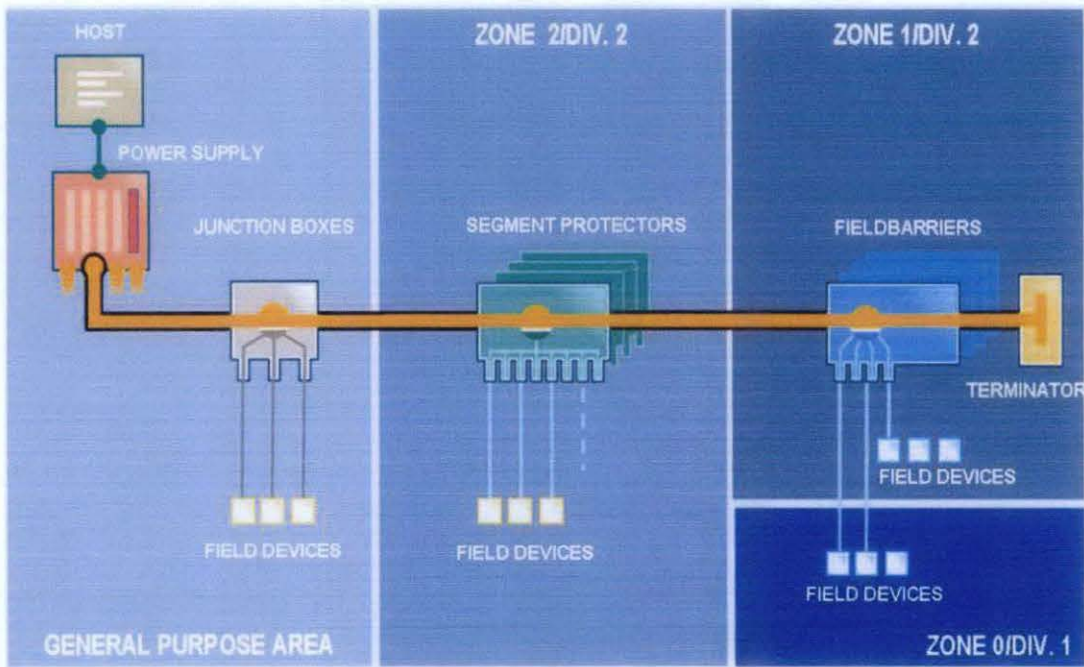
- 10.5.1.15 In "Process", change the Actual Mode to "OOS"
  - 10.5.1.16 Click "Ranges"
  - 10.5.1.17 Change the XD\_SCALE and OUT\_SCALE
  - 10.5.1.18 Click OK
  - 10.5.1.19 Observe the device using the 375 Communicator. The changes of the device will be the same as the previous changes in the host
- 10.5.2 Using 375 Communicator:
- 10.5.2.1 At the field site, connect the 375 Communicator
  - 10.5.2.2 Using the device, select "Fieldbus Application"
  - 10.5.2.3 Select Online.  
*\*Note: The communicator will upload information on all devices connected to the segment.*
  - 10.5.2.4 Select one device that needs to be rescaled.  
*Note: the communicator will take some time to upload the device*
  - 10.5.2.5 Select AI block.
  - 10.5.2.6 Select "Quick Config". Change Mode to "OOS" (previous mode in "Auto"). Change XD Scale (Transducer Block) and Output Scale. Click 'Send'. Change mode back to "Auto".  
*Note: This step may be performed using other than "Quick Config" option.*
  - 10.5.2.7 Monitor the faceplate and effect on the other devices.

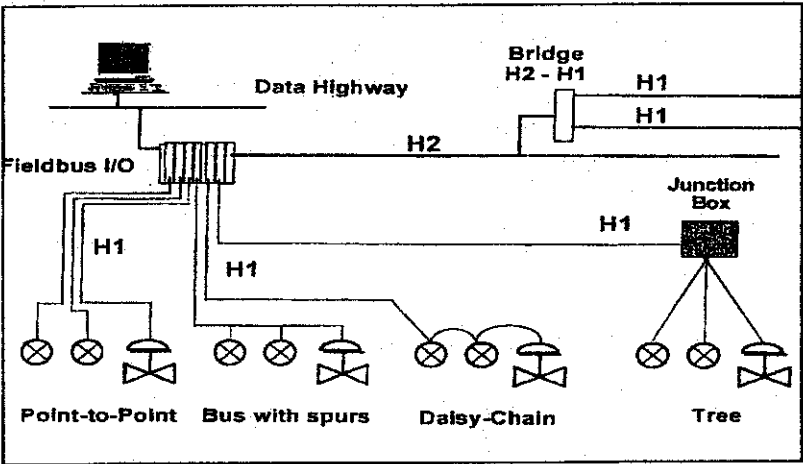


*Note: Action by Host and Communicator cannot be performed on the same device at the same time. At one time, only either Host or the communicator may change the setting of the device.*

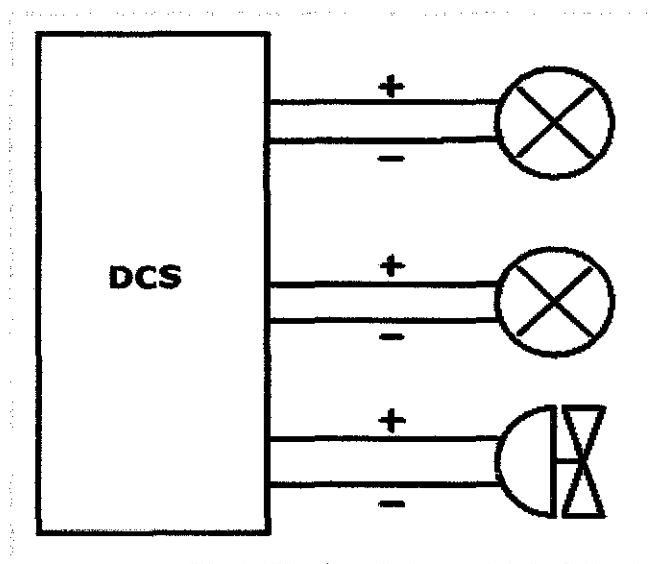
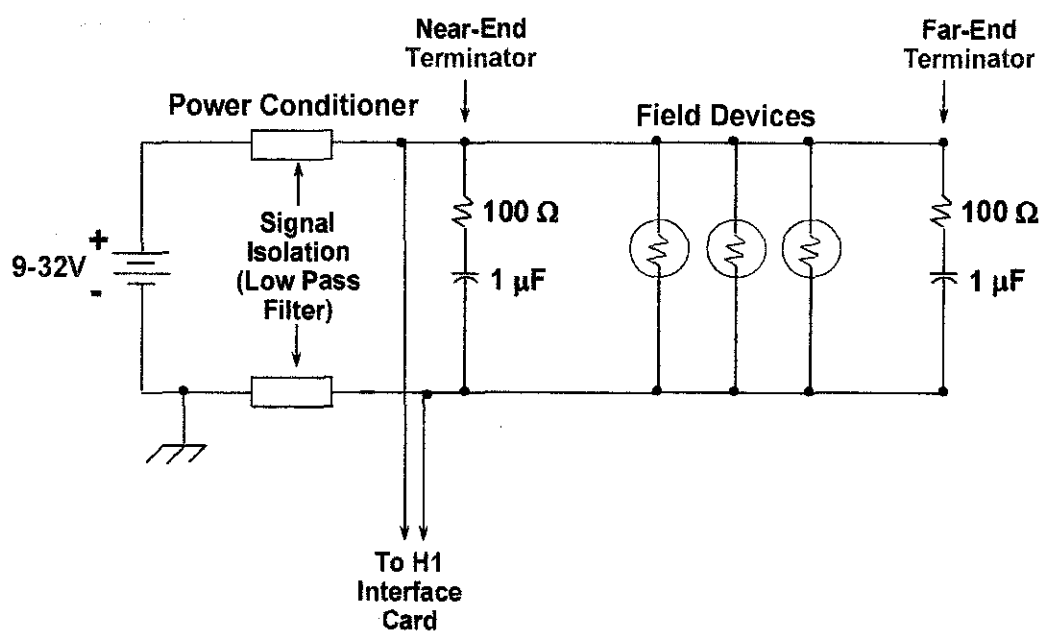
APPENDIX 4

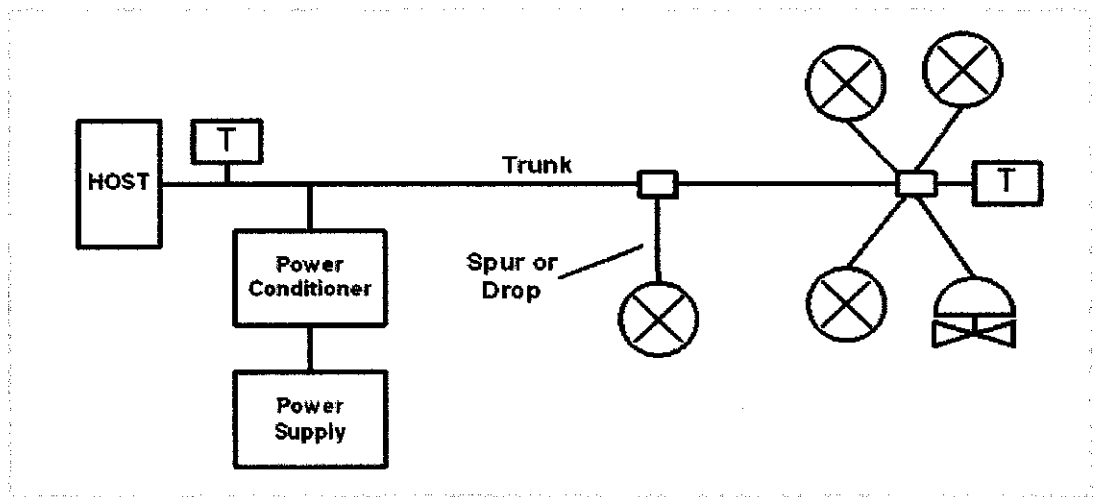
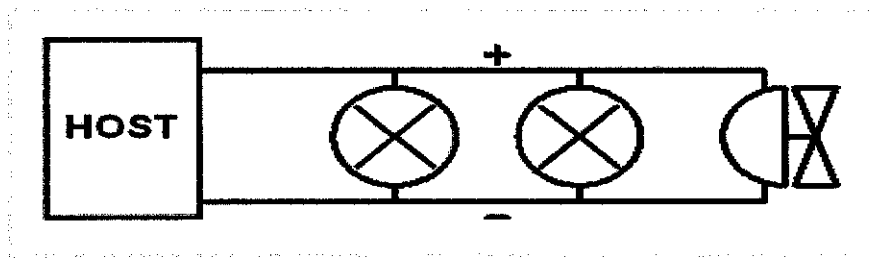






Type	Cable Description	Size	Max Length
Type A	Shielded, twisted pair	#18 AWG (.8 mm <sup>2</sup> )	1900 m (6232 ft.)
Type B	Multi-twisted-pair with shield	#22 AWG (.32 mm <sup>2</sup> )	1200 m (3936 ft.)
Type C	Multi-twisted pair, without shield	#26 AWG (.13 mm <sup>2</sup> )	400 m (1312 ft.)
Type D	Multi-core, without twisted pairs and having an overall shield	#16 AWG (1.25 mm <sup>2</sup> )	200 m (656 ft.)





Appendix 5

Task / Month	Jan	Feb	March	April	May	Aug	Sept	Oct	Nov	Dec
Proposing the Topic										
FELDBUS Research										
HONEYWELL Instruction Manual										
Familiarization with Foundation FIELDDBUS Lab /EMERSON TRAINING										
Final Report 1 (1 <sup>st</sup> Draft)										
Final Report 1										
Oral Presentation FYP1										
Basic Interoperability Test										
Plant model										
Final Report										
Final Presentation FYP2										